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Technical Report

U.S. Tar Sand Oil Forecasts (1985-1995)

November 1979

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Technical Report

U.S. Tar Sand Oil Forecasts (1985-1995)

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TR/ES/80-02

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ABSTRACT

TR/ES/80-02

U.S. Tar Sand Oil Forecasts, 1985-1995

This Technical Report forecasts production of oil from domestic tar sands through 1995 under low, medium and high world oil price scenarios. It also includes background information such as the extent, nature, and location of tar sands in the United States, as well as the status of technology and a few other pertinent aspects of this potential future source of oil. No appreciable amount of tar sand oil production is anticipated during the forecast period if world oil prices are no higher than those assumed for the medium world oil price path. If the high world oil price trajectory prevails, however, production at a rate of about 50,000 barrels per day is foreseen in 1995.

Released for Printing: February 6, 1980

PREFACE

This report was prepared by the Energy Information Administration (EIA) to assess domestic tar sand resources and forecast production to 1995 from those resources. These forecasts are included in the 1978 EIA Annual Report to Congress (ARC), published in July, 1979.

Several worldwide events have occurred recently which could not be incorporated in this analysis. They include price increases announced by the Organization of Petroleum Exporting Countries in late March and early July 1979.

Quite a number of uncertainties necessarily are involved in developing forecasts for a U.S. tar sand industry. These uncertainties derive largely from the early stage of technological development, lack of detailed knowledge about the character of the tar sand deposits, and a need for a more thorough evaluation and market analysis relative to the tar sand oil to be produced.

Alternate premises and assumptions could be used to provide some of the bases for the forecasts. Incorporating alternate scenarios into the forecasting procedure is beyond the scope of this study. However, a section headed "Uncertainties and Alternate Concepts" is included, in which the major alternate possibilities are recognized. Making supply forecasts over the midterm is a continuing function of the

EXECUTIVE SUMMARY

The continued worldwide concern over the international oil market and the limited and uncertain energy supplies is causing renewed interest and urgency in the development and expansion of a U.S synthetic fuels industry. In July 1979, the House of Representatives approved a bill to create a synthetic fuels industry capable of producing the equivalent of 500 thousand barrels daily of synthetic oil by 1985 and 2 million barrels daily by 1990, by means of Government use or resale and other measures. The President's energy message of July 15, 1979, set forth a new energy plan, which includes a proposed Energy Security Corporation that would invest $88 billion over the coming decade in projects to produce synthetic fuels.

The tar sand oil study described in this report does not consider the possible impact of such programs on the timing of initiating the first commercial tar sand oil plants in the United States nor the rate of expansion of the industry.

This report provides an overview of U.S tar sand oil resources and EIA's latest production forecasts. The forecasts range from zero to 50 thousand barrels daily for 1995, as shown in the following tabulation:

Tar Sand Oil Production (MB/D)

	(Low) D	(Med) C	(High) B
1985	0	0	0
1990	0	0	0
1995	0	0	50

D, C, and B correspond to the following assumed world oil prices in 1978 dollars:

D - $15.00 in 1985, $15.00 in 1990, and $16.50 in 1995

C - $15.00 in 1985, $18.50 in 1990, and $23.50 in 1995

B - $21.50 in 1985, $23.50 in 1990, and $31.50 in 1995

The forecasts are based on specific assumptions, estimated, minimum-acceptable, tar sand oil prices and assumed world oil price trajectories D, C and B. The assumptions as to future world prices are used in the EIA Annual Report to Congress, 1978, and were made prior to the late March and early July OPEC price increases.

U.S. tar sand oil resources in place are estimated at up to 33 billion barrels,[1] of which about 28 billion barrels are located in Utah.[2]

1/ See reference 7.
2/ See reference 8.

The bitumen obtained from tar sand is too viscous (above 1,000 poises at 50° F) for transport in an unheated pipeline without first being upgraded. Crude tar sand oil, or bitumen, is heavy, usually 6-10° API, as well as viscous. There are a number of instances where the gravity falls above or below this range. Tar sand oil is deficient in hydrogen as compared with lighter petroleum crudes. By hydrogenation (hydrotreating and/or hydrocracking), it can be upgraded to a light (35° to 40° API) sweet syncrude, comparable to the highest quality light petroleum crudes.

Historical Aspect

In the United States, tar sands have been recognized for many years as potential sources of oil. However, domestic tar sands have not attracted much sustained interest as an energy source until recently. Prior to current experimental projects, research and development activity on Utah's tar sands, where interest ultimately would logically center, had been limited to a few sporadic short term small scale efforts.[1/]

This rather scant attention in the past probably reflects a view on the part of industry that spending appreciable sums of money on tar sand research and development activities

1/ See reference 3.

does not appear warranted until the economic outlook for tar sand appears brighter. It may also relate to the domestic tar sand oil resource being relatively small in comparison to petroleum and shale oil resources. Another factor may relate to resource availability, especially on public domain lands.

Still another consideration is that petroleum and/or oil shale occur in some of the tar sand areas. In some instances, e.g., where tar sand and oil shale deposits are interbedded or petroleum and tar sand deposits superimposed, exploitation of one resource may impact seriously on future development of the other(s).

At present a considerable amount of research and development is in progress on processing methods for recovering oil from domestic tar sands. However, processes have not yet been developed to the point where they are ready for commercial application.

Mining and Plant Extraction

It may be possible to adapt some of the Athabasca hot water processing technology to some U.S. tar sands. However, the deposits in Utah and other deposits in this country

have characteristics of their own that require development of different or modified recovery techniques. Also, adequacy of water supplies will be a consideration.[2/]

A field test was conducted in recent years on an above ground method of processing tar sand mined from the Asphalt Ridge deposit. The operation was conducted by Aminoil USA, Inc., using a combination solvent and hot water extraction process.

Rio Tinto Holding Company, London, England, reportedly is planning to move a 500 barrel a day solvent extraction pilot plant from Alberta, Canada, to a site in Utah. The intention is to determine whether this pilot plant, which has been operating on Athabasca tar sand, will perform satisfactorily when processing tar sand from one of the deposits in Utah.

Several companies and universities are conducting laboratory and pilot plant experimentation on a variety of extraction processes. These experiments include anhydrous solvent processes, solvent and hot water combinations, solvent and cold water combinations, and thermal processes, one of which uses the fluidized bed technique.

In Situ-Oil Recovery

Developing a viable in-situ technology will be essential to economic recovery of oil from the deeper deposits. It possibly could render economically feasible the recovery of

2/ See reference 3.

oil from deposits of lower bitumen saturation than the minimum grade for which mining and above ground processing would be economically feasible. It may be found preferable for some deposits where either mining or in-situ operations could be applied satisfactorily.

The U.S. Department of Energy is conducting field experiments on in-situ recovery of oil from the Northwest Asphalt Ridge tar sand deposit near Vernal, Utah. The work has been in progress for several years and is continuing. The techniques under investigation include in-situ combustion and steam drive. This work is expected to result in development of viable in-situ technologies, which can be used in commercial projects by industry.

2. RESOURCES

Domestic resources of tar sand oil in place are estimated at up to 33 billion barrels.[1/] The bulk of these resources is in Utah, whose in place resources of oil from tar sands are estimated at about 28 billion barrels.[2/] These estimates do not include the heavy oil desposits contained in subsurface reservoirs. Based on present knowledge, the in place U.S. heavy oil resource is estimated to be larger than the domestic in place tar sand oil resource.

The in-place U.S. heavy-crude-oil resource was estimated to be 106.8 billion barrels as of January 1, 1966.[3/] This resource represents crude oil having an API gravity of 25° or less. It does not include the bitumen in tar sand deposits. The proved reserve of heavy oil, as of January 1, 1966, i.e., heavy oil then considered to be ecomonically recoverable by operating methods then in effect, was 5.2 billion barrels. In 1966 the heavy-oil production forecast for the years 1966-1980, inclusive, was 5.8 billion barrels. Therefore, the current in place U.S. heavy oil resource (25° API gravity or less) is estimated to be about 100 billion barrels.

An estimate of the bitumen obtainable by known mining methods for deposits less than 500 feet deep was made in 1964, based on a compilation of information then available from numerous

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1/ See reference 7.
2/ See reference 8.
3/ See reference 9.

sources. The tar sand resources ("reserves" is the term that was used) on this basis were estimated at 2.5 to 5.5 billion barrels.[4/] These figures represent oil in place; no distinction was made between oil in place and recoverable oil. A recent study of the economic potential of tar sand deposits in Utah indicates that a net economic recovery of about 2 billion barrels from two major deposits in Utah appears possible using in-situ techniques.[5/] However, recovery of this amount of oil would be contingent on making advances in thermal in-situ tar sand oil recovery technology that are thought to be achievable.

In California, the oil recoverable from tar sands by surface mining followed by extraction processing is estimated to exceed 200 million barrels.[6/] The largest, single, minable tar sand deposit in California is in the Edna district in San Luis Obispo County. Here, the bituminous sandstone forms prominent cliffs on both sides of a narrow valley and extends several miles in a broad belt. There is little overburden. From 9 to 16 weight percent asphalt is reported. The recoverable resource shallower than 250 feet is estimated to be between 141 million barrels and 166 million barrels. Some of the deposits in California also are candidates for application of in-situ production techniques.

4/ See reference 1.
5/ See reference 5.
6/ See reference 1.

In New Mexico, one of several known tar sand outcrop areas is regarded as having commercial potential. This area is 10 miles north of Santa Rosa in Guadalupe County. It consists of asphalt-impregnated sandstone, approximately 20 feet thick. In this area, a small deposit south of the Pecos River covers about 100 acres. Two large deposits north of the river extend over 4530 acres.

There are at least 17 areas in Texas where bitumen-impregnated limestones and sandstones are known to exist. These are mostly in a broad, northeast-southwest band of Cretaceous sediments outcropping across the middle of the state. The state's most important deposit by far is in southwestern Uvalde County and southeastern Kinney County. This deposit ranges from 63 to 124 feet in thickness, with varying amounts of overburden. In four areas near one another totaling 1403 acres, the Uvalde deposit has a bitumen content ranging from 5 to 15 percent by weight and averaging about 15 to 17 gallons per ton.[7/] An in-situ operation currently is producing several hundred barrels per day from this deposit.

Kentucky has significant tar sand oil resources in 12 counties. A single trend in 5 counties in the west-central part of the State accounts for most of the resources. Over 500 million tons of oil-impregnated material are estimated to be obtainable from tar sand

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7/ See reference 1.

beds ranging from 15 to 30 feet thick, underlying about 15 feet of overburden. Bitumen content generally is in the range of 10 to 15 gallons per ton[8/], which corresponds to about 4 to 6 weight percent.

Tar sand deposits are known to exist in a number of other States, but they have not generated as much interest as those in Utah and the other states mentioned in the foregoing discussion.

Utah has 6 "giant" deposits out of the State's total of 51 known tar sand deposits. A deposit is classified as giant if it contains more than 500 million barrels of bitumen. In addition to the 6 giant deposits, 5 are large enough or favorably enough situated to offer commerical possibilities. Some of those 5 are categorized as very large (from 100 to 500 million barrels) and the others large (10 to 100 million barrels).

All six of the giant deposits are estimated to contain more than 1 billion barrels each and are in eastern Utah. Four are in the Uintah basin in northeastern Utah; the other two are in the southeastern part of the State. The names, locations and estimated in place oil contents of the four deposits in the Uintah basin are as follows[9/]: (1) P.R. Spring

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8/ See references 1.
9/ See references 4 and 8.

in Uintah and Grand Counties, containing 4 to 4.5 billion barrels; (2) Sunnyside, northeast of the town of Sunnyside in Carbon County, containing 3.5 to 4.0 billion barrels; (3) Hill Creek in Uintah County, containing 1.2 billion barrels; and (4) Asphalt Ridge, southwest of Vernal in Uintah County, containing about 1.1 billion barrels. The two in southeastern Utah are (1) Tar Sand Triangle in Garfield and Wayne Counties, containing 16 billion barrels and (2) Circle Cliffs in Garfield County, containing 1.3 billion barrels.

3. DESCRIPTION OF MINING, PROCESSING AND UPGRADING FACILITIES

Early commercial development of tar sands in the United States, may involve both in-situ operations and surface mining followed by processing in equipment designed to extract the oil.

The various groups interested in developing the Athabasca deposit in Alberta, Canada, recognized, early on, that the bulk of that deposit, the deeper lying material, cannot be mined ecomomically and that its oil must be recovered by in-situ methods. Work to develop such methods, for application to the Canadian tar sands, has been in progress for many years with some noteworthly achievements. However, the plants now operating are of the surface mining, above ground processing type.

Equipment for mining tar sand in Utah may primarily consist of: elevating scrapers, bulldozers, drills, draglines, blasting equipment, front-end loaders and large haulage trucks. There may also be miscellaneous items of mobile equipment such as graders, pick up trucks and water trucks. The kinds of processing equipment and facilities used will depend on which process or processes now under development will be selected for commerical application. Equipment for in-situ operations is expected to be similar to that used in tertiary steam and combustion oil recovery operations in some of the conventional oil fields.

Great Canadian Oil Sands Plant

To provide a general concept of the complexity that may be involved in a future industrial plant in Utah using one type of aboveground separation process, a brief description follows of the Great Canadian Oil Sands, Inc., (GCOS) extraction plant. This process and the technology embodied in the extraction plant represent many years of laboratory and pilot plant experimentation.

In the GCOS system the tar sand from the mine in lump form is fed to a conditioning drum. This conditioning drum is a large (17 ft. dia., 51 ft. long), horizontal, rotating vessel. Hot water and dilute caustic soda are fed into the drum along with the tar-sand lumps. Steam is injected under the surface of the pulp to maintain a drum outlet temperature of approximately 180° F. Heat and agitation, thus applied, break down the lumpbinding forces; successive layers of each tar sand lump slough off as they becomed warmed. Control of pH in the range of 8.0-8.5, by adding dilute caustic, greatly aids the process.

Conditioned pulp, which is about 70 percent solids, is discharged onto a vibrating screen, where any remaining lumps and tramp iron are removed; the underflow then is pumped as a slurry to separation cells. In each separation cell the bitumen picks up enough air to produce a froth

having a specific gravity of about 0.7. Most of the bitumen rises to the top, floats as a froth and is skimmed off by rakes. The froth contains water and sand as well as bitumen and air. The froth is diluted with naphtha and sent to a battery of centrifuges of conventional design where the oil-naphtha phase is separated from the water and inorganic minerals. Coarse minerals or sand, which settle to the bottom of the separation cell plus the relatively small amount of solids removed by the centrifuges are pumped to a tailings pond.

A middlings stream is withdrawn from the layer beneath the froth in the separation cells. A portion of this stream is recycled to the conditioning drum and the remainder, called the dragstream, is sent to scavenger cells and froth settlers. Withdrawal of the dragstream prevents buildup of fines in the separation cells. The middlings stream is mostly water but contains some bitumen and suspended fine mineral particles. The scavenging cells are very large, conventional, air-flotation units. After a froth settling step, the froth thus obtained from the middlings stream goes to the centrifuges along with the forth from the separation cell. Thus, most of the bitumen from the middlings stream is recovered.

Upgrading

Upgrading bitumen to a high quality oil in the United States is expected to resemble its Canadian counterpart and will be similar to a shale oil upgrading procedure. It probably will include a coking step. It will require a hydrogen manufacturing plant, hydrotreating facilities for naphtha and gas oil, a sulfur recovery plant and an ammonia recovery plant.

A mild-upgrading facility for tar sand oil would be much less elaborate and less expensive. It might resemble its shale oil counterpart.[1/]

1/ See Technical Report TR/ES/79 Shale Oil Forecasts, 1985-1995.

4. ASSUMPTIONS

In addition to the basic assumptions stated below, some assumptions were made in regard to certain specific features of the concept on which the forecasts are based. Assumptions concerning a particular feature are stated where the feature is discussed.

The basic assumptions are as follows:

- Every tar sand oil recovery process to be used for commerical production will first be demonstrated in a field pilot or demonstration project.
- A period of 4.5 years typically will be required for the demonstration phase, from the time a decision is made to build a demonstration facitity until the results of its operation are available for designing a commercial plant.
- The lead time for commerical projects will be 7 years, plus or minus 1 year, depending on the location and size of the project.
- Commercial projects will not be initiated in anticipation of a rise in world oil prices; that is, a decision to proceed with construction of a commerical facility will be delayed until the world oil price has actually risen high enough to render tar sand oil competitive at the minimum acceptable price for such oil.
- A discounted cash flow (DCF) rate of return of 15 percent based on total investment will be required for pioneer tar sand plants.

In regard to the first assumption, the field pilot or demonstration step limits the risk involved in scaling a process and equipment up to commercial proportions. It provides engineering data needed for designing a commercial project.

The time required for the field pilot or demonstration phase could vary considerably. The 4.5 years is estimated as follows: 18 months for selecting a site, acquiring tar sand resources and land or the use of land, complying with environmental requirements and designing the project; 12 months for procuring and installing equipment; 6 months for operating the project, delineating problems that may be encountered and devising solutions; 6 months for making alterations to eliminate those problems and improve the performance of the facility; and 12 months for operating the improved project (possibly under more than one set of process parameters).

Of course, much less time would be required to move a pilot plant from its location in Alberta, Canada, to a site in Utah and operate it for a test period.

The lead time assumed for a commercial project in this analysis begins when an operator decides to build a plant. It ends when oil production approaches the design capacity of the project, which is assumed to be one year after startup.

The lead time could vary from one project to another. In a typical project the time might be consumed as follows: 1 year for acquiring private land or obtaining the lease of a tract of public domain or state-owned land; 1 year for project design; 2 years for preparation of an environmental impact statement, conducting baseline environmental monitoring, securing all the necessary permits, acquiring water rights, and bringing water, roads, utilities, etc., to the site; 1.5 years (beginning during the 3rd year) for procuring equipment; 2 years for installing the equipment (building the plant), beginning middle of 4th year; and 1 year of operation to bring the production rate up to about 80 or 90 percent of the design rate.

There is a question as to whether operators would commit funds to a project in anticipation of a rise in world oil prices. In this analysis, it is presumed that operators would take a conservative position in this matter particularly for a pioneer project that has a large capital requirement.

The 15 percent rate of return is used in some economic prognostications relative to pioneer plants using new technologies. Other return rates are used also. It would be desirable to obtain a concensus on this point relating specifically to pioneer tar sand projects.

5. MINIMUM-ACCEPTABLE PRICE

Cost estimates and economic analyses for recovering oil from U.S. tar sands based on production experience are not available at this time. In the future, reasonably dependable cost estimates for domestic tar sand operations will be founded on specific technologies, after pilot and/or demonstration operations have provided the data needed for the process design of a commercial-size hypothetical or planned facility.

An approximation of the cost and economics of a little-known operation may be obtained by considering the analogy of a better-known operation, similar enough to warrant an expectation that the cost of the two should be comparable. This is the method used to arrive at a minimum-acceptable price for recovering oil from U.S tar sands. The analogy in this case is between an Athabasca tar sand operation and a Utah tar sand operation. However, because of the rather considerable differences between the well-known and poorly known operations, the probable magnitude of cost differences corresponding to the differences in character of the two operations is hard to assess. The uncertainty is related to differences in the characteristics of the processes for separating oil from sand, mining techniques, geological and topographical features of the areas in which the deposits lie, climate, and other aspects of the two operations.

Two plants are now operating on the Athabasca tar sands of Alberta, Canada. One, the Great Canadian Oil Sands, Inc., (GCOS) plant has been in operation for more than 11 years. It operated at a loss until 1974. The plant is currently producing approximately 50,000 barrels daily. It now yields a modest profit. The other, Syncrude, Inc., started up the first of two production trains in September of 1978.

Synthetic oil production has been about 50,000 barrels daily, approximately 80 percent of the design capacity of this production train. Cumulative production to July 1979 is about 10 million barrels. Fire knocked out a fluid cracker unit in July 1979. This unfortunate incident is but one of a prolonged series of start-up problems encountered by Syncrude.

The Athabasca deposit is estimated to contain 720 billion barrels of oil.[1/] Estimates of oil in place in three other cretaceous tar sand deposits in Alberta are as follows: Cold Lake (159 billion barrels); Peace River Bluesky - Bullhead (64 billion barrels); and Wabasca (24 billion barrels). About 10 percent of the Alberta tar sand deposits can be mined economically by surface mining methods. The surface minable portion of the Athabasca deposit is large, level, thick and continous.

1/ See reference 2.

Most of Utah's tar sand deposits are relatively small, thin and discontinous. Some occur in relatively flat areas and some in mountainous areas. The Sunnyside deposit has a thick pay zone.

The Asphalt Ridge bituminous sandstone can be partially mined without blasting. It can be mined with bulldozers and front-end loaders. GCOS employs blasting at their Athabasca site; Synecrude does not.

Mining of the other 5 principal Utah deposits will require drilling and blasting. Also, in areas of those 5 deposits to be mined by open pit methods, the overburden probably will require drilling and blasting. It is expected that in-situ methods can be applied to deep deposits and some of the shallower ones as well.

The Utah tar sands are generally not as rich as those of the Athabasca deposit. One statement concerning the Asphalt Ridge deposit gives the bitumen content as 13 to 27 gallons per ton,[2/] which corresponds to 5 to 11 weight percent, approximately.

2/ See reference 4.

One estimate of an average value for the Sunnyside deposit is about 20 gallons per cubic yard[3/] (about 4.5 weight percent). However, some parts of the deposit may be richer.

Over half of the Athabasca deposit contains more than 13 weight percent bitumen. About 30 percent of the deposit is leaner than 10 weight percent bitumen. The lower economic limit for a mining operation has been estimated at approximately 8 percent bitumen.[4/]

There is no muskeg (a semi-liquid blanket of partially decayed vegetable matter) to contend with in U.S tar sand operations, as there is at the Athabasca deposit. The muskeg in the Athabasca area is first drained for about two years, after creating a network of drainage channels. It is then removed while frozen and placed in dyked areas. When it thaws, it becomes a liquid pulpy mass, which must be contained.

There are other, less important, differences between the Athabasca operation and its Utah counterpart, which are not enumerated here. It appears that the main differences between the two can be expected to largely offset one other in their effects on cost per barrel of output.

3/ See reference 4.
4/ See reference 5.

The initial capital cost for the Syncrude, Inc., tar sand plant was estimated in 1976 dollars at $2.5 billion. However, the cost of the pipeline to Edmonton, about $100 million, is included in that figure. Subtracting the $100 million from the $2.5 billion leaves $2.4 billion. This figure translates to $2.7 billion in 1978 dollars. This plant is designed for an output of 125,000 barrels per calendar day of upgraded oil, which is referred to as syncrude. As will be described in the "Development Pattern" section, the forecast envisions a 50,000 barrel a day production facility at the Sunnyside deposit in Utah. Thus, the Syncrude, Inc., plant has 2.5 times the capacity assumed for the Sunnyside project.

Using the exponential factor method of approximating a capital cost for the Sunnyside plant, based on the cost of the Syncrude plant, a capital cost figure was computed. The $2.7 billion was divided by the 0.8 power of 2.5. The capital cost figure thus computed is $1.3 billion for the Sunnyside plant.

The operating cost, including hydrotreating, is roughly estimated at $5 per barrel. To yield a 15 percent DCF return rate, a price of about $24 per barrel would be required for highly upgraded tar sand oil.

For this forecasting procedure, $24 per barrel in 1978 dollars was used as the minimum-acceptable price for highly upgraded oil from Utah tar sands.

As in the case of shale oil[5/], it is presumed that a lower quality, mildly upgraded tar sand oil could be produced at a price roughly $4 lower than that for the high quality oil. Accordingly, for this forecast, the minimum-acceptable price for mildly upgraded tar sand oil is considered to be $20 per barrel in 1978 dollars.

For shale oil, hydrostabilization has been proposed as one way of upgrading crude shale oil to a pipelineable, saleable product. This type of hydrogen processing uses only a small fraction of the amount of hydrogen required for hydrotreating. Whether this type of mild upgrading would be practical for tar sand oil or whether some other treatment, such as a moderate thermal treatment, would be appropriate would have to be determined. Also, an investigation would have to be made as to whether such a mildly upgraded oil would be a satisfactory refinery feedstock, or whether it could be blended with certain conventional petroleum crudes to make a satisfactory feedstock.

5/ See Technical Report TR/ES/79 Shale Oil Forecasts, 1985-1995.

As mentioned earlier, in-situ methods of recovering oil from Utah tar sands are under development. They may or may not predominate during the early stages of the tar sand industry in Utah. It seems plausible to expect that a mix of technologies may be used; one may be more suitable than another for a specific site. Capital costs are expected to be smaller and operating costs greater for in-situ operations than for mining and aboveground processing. Information available at this time is not adequate to enable one to conclude that minimum-acceptable prices for tar sand oil produced by in-situ operations would differ greatly from the prices mentioned above.

6. TAR SAND OIL VALUE AND TRANSPORATION COST

As will be described in the next section, "Development Pattern," it is assumed that Utah tar sand oil will be marketed principally in the Chicago area. In the scenario, used for this forecasting procedure, it would be transsported by a spur pipeline to a larger pipeline that would carry both shale oil and tar sand oil from northwestern Colorado to the Chicago area (See section headed "Uncertainties and Alternate Consepts" regarding other possible markets).

In this study, highly upgraded (hydrotreated) tar sand oil, because of its superior quality, is considered to have a value 35 cents per barrel above the world oil price. This premium was used for shale oil[1/] and is assumed to apply also to tar sand oil.

The pipeline transportation cost from northwestern Colorado to Chicago is estimated at 73 cents per barrel, and from the Utah production site to northwestern Colorado at 20 cents per barrel. Accordingly the total estimated pipeline transportation cost for tar sand oil is 93 cents per barrel. For imported oil, landed at New Orleans, La., the pipeline transportation cost to Chicago is about 38 cents per barrel.

1/ See Technical Report TR/ES/79 Shale Oil Forecasts, 1985-1995.

Thus, the pipeline transportation cost for tar sand oil is estimated to be 55 cents per barrel more than that for imported oil landed on the Gulf Coast.

Of this 55-cent per barrel transportation-cost penalty for tar sand oil, 35 cents is offset by the 35-cent premimum highly upgraded tar sand oil is expected to command over the world oil price because of its superior quality. The net penalty then for highly upgraded tar sand oil is 20 cents per barrel. Accordingly, as an example, when the world oil price is $21.50 per barrel landed on the Gulf Coast, tar sand oil would sell for 20 cents less or $21.30 at the production/ upgrading facility in Utah.

Mildly upgraded tar sand oil is assumed to have the same value as its shale oil counterpart.[2/] The quality of a mildly upgraded (hydrostabilized) shale oil was judged in 1976 to be worth $12.50 per barrel. At that time the world oil price was $13.50 per barrel. Thus, aside from any consideration of pipeline transporation cost, the mildly upgraded oil was worth $\frac{12.50}{13.50}$ or 92.59 percent a much as imported oil. In this study, that relationship is assumed to hold true for mildly upgraded tar sand oil and to continue throughout the forecast period. The tar sand oil is at a further disadvantage

2/ See Technical Report TR/ES/79 Shale Oil Forecasts, 1985-1995.

as compared with imported oil because of the greater pipeline transportation cost (55 cents per barrel more from the Utah site to Chicago than from the Gulf Coast Chicago).

The foregoing is summarized in the example that follows. When the world oil price is $21.50 per barrel, mildly upgraded tar sand oil would be worth 0.9259 x $21.50 or $19.91 per barrel, if there were no disadvantage because of pipeline transportation cost. In other words, as shown in Table 1, it would suffer a penalty of $1.59 (obtained by subtracting 19.91) on average imported oil. A further subtraction of 0.55 per barrel from the world oil price, to take account of the transportation cost differential, is required to obtain the price of mildly upgraded tar sand oil as it enters the pipeline in Utah. Thus, a shown in Table 1, the tar sand oil price in this example is computed as follows: $21.50-$1.59-$0.55 = $19.36.

Table 1 Tar Sand Oil Values Corresponding to Various Landed World Oil Prices (1978 dollars)

World Oil Price		a/ Adjustment to WOP to Obtain Value of Mildly Upgraded Tar Sand Oil		Value of Mildly Upgraded Tar Sand Oil	Value of Highly Upgraded Tar Sand Oil
Case C	Case B	because of poorer quality	because of higher pipeline cost		
15.00		-1.11	-.55	13.34	14.80
18.50		-1.37	-.55	16.58	18.30
23.50		-1.74	-.55	21.21	23.30
	21.50	-1.59	-.55	19.36	21.30
	23.50	-1.74	-.55	21.21	23.30
	31.50	-2.33	-.55	28.62	31.30

a/ Only cases C and B are shown here because tar sand oil does not becomes competitive with the low world oil prices, Case D, by 1995.

7. DEVELOPMENT PATTERN

The development pattern described in this section represents one possible scenario. There are other possible scenarios, as well as variations of this development pattern. Alternate courses some tar sand experts think commercial development is likely to take are described in the section "Uncertainties and Alternate Concepts."

It is postulated that plans for one or more field demonstration projects will be initiated in 1980 or 1981. Is is anticipated that one or more of the technologies embodied in these demonstration projects will be ready for commercialization by 1986.

It is assumed that the first commerical tar sand project to operate in Utah will utilize a portion of the Asphalt Ridge deposit. A nearly simulataneous development is assumed to utilize a portion the Sunnyside deposit. Development of the Tar Sand Triangle deposit appears to be the next logical target. Although the Tar Sand Triangle deposit is by far the largest of the Utah deposits, it is doubtful whether development of this deposit will begin quite as soon as development of Asphalt Ridge and Sunnyside deposits. This deposit is generally flat and thick. A large part is covered by a considerable amount of overburden. On the average, it appears rather lean[1/], but should be amenable

1/ See reference 4.

to in-situ recovery.[2] Possible environmental restrictions and commitment of lands in and near Tar Sand Triangle to scenic and recreational uses may tend to delay development. A portion of the area is covered by Glen Canyon National Recreation Area. Canyonlands National Park, though not adjacent, is across the Colorado River east of this tar sand area. It might not have any impact, so far as delaying development is concerned. Lake Powell is south of the deposit; it may not be in close enough proximity to exert any impact. Tar Sand Triangle is mostly on public domain, though there is a scattering of State-owned sections.

The P.R. Spring deposit has two to six pay zones that are widely separated by barren material.[3] Properties of the tar sand deposit in Three mile Canyon area have been determined from core samples.[4] That area is in the extreme northeast corner of the deposit. Overall, the P.R. Spring Deposit is thought to be less attractive for early commerical development than the three aforementioned deposits.[5] Circle Cliffs ranks next to last, mainly because of poor bitumen saturation. The Hill Creek deposit has much poorer prospects in terms of oil content per square mile than any of the other five giant deposits.[6]

2/ See reference 5.
3/ See reference 4.
4/ See reference 6.
5/ See reference 4.

This forecast assumes that the bulk of the tar sand oil production within the forecast period will be in Utah but that some will occur in California (see section headed "Uncertainties and Alternate Concepts" regarding other possibilities). Some of the California deposits may be somewhat richer than those in Utah and some are not too far from existing refineries. Because of these factors, it is believed that there is a good likelihood of a commerical tar sand development in California being undertaken a little earlier than those in Utah.

The Asphalt Ridge deposit is near the town of Vernal, Utah. Ownership problems are minimal. Water supplies are adequate for the operations envisioned. Mining will be relatively simple and probably less expensive for the minable portion of this deposit than for the other Utah deposits. Sampling and evaluation of this deposit have been appreciable. Pilot plant studies are being conducted on methods of aboveground processing Asphalt Ridge tar sand to separate the bitumen from the sand. In-situ oil recovery experiments are being conducted on the Northwest Asphalt Ridge deposit.

The Sunnyside deposit is large enough to be able to support several projects, each having a production capability of 50,000 barrels a day. One possible plant site is the area

around a quarry, where asphaltic material was mined prior to 1950 by the Rock Asphalt Company of Utah. A cross-sectional diagram of a ridge near this point shows 680 feet of overburden and about 1,160 feet of pay, containing some barren layers. The pay zone is more than one-half mile wide.[7/]

It is assumed that the initial Asphalt Ridge facility will be sized to produce 10,000 barrels of upgraded tar sand oil per calendar day. The Sunnyside plant is assumed to be designed to produce 50,000 barrels per day.

The decision to go ahead with the Sunnyside plant will be made, it is assumed, about the same time as the decision on the Asphalt Ridge plant. However, prior to construction of the Sunnyside plant, it will be necessary to build some roads over mountainous terrain and establish community facilities. Also, it will be desirable to conduct a core drilling program. Furthermore, it probably will take a little longer to design and build the larger plant. Because of these factors, the Sunnyside plant is not expected to be ready for startup until about a year and a half after the startup of the Asphalt Ridge plant.

It is assumed that a tar sand oil pipeline will be built to transport the tar sand oil to a shale oil pipeline in Colorado, which will carry the tar sand oil, as well as shale oil, to the Chicago area. The tar sand oil pipeline will run from

7/ See reference 4.

the Sunnyside plant to northwestern Colorado, where it will terminate at its junction with the shale oil pipeline. The tar sand oil pipeline will be routed through the Asphalt Ridge plant vicinity and will transport the oil from that plant as well as the oil from the Sunnyside plant to the shale oil pipeline.

Initial California tar sand oil production is assumed to precede that in Utah. The California facilities are assumed operating at a 10,000 barrel a day level about a year before startup of the Asphalt Ridge plant.

8. FORECASTS

The forecasts that follow are based on the previously discussed assumptions and minimum-acceptable tar sand oil prices, as well as three assumed world oil price trajectories (C, B, and D). They also take into account the timing of technologic readiness.

Table 2 shows when tar sand oil becomes competitive with imported oil if minimum-acceptable prices in 1978 dollars are $24 per barrel for highly upgraded tar sand oil and $20 per barrel for mildly upgraded tar sand oil (see section "Minimum-Acceptable Price" for derivation of these estimated prices). Such information is shown for only medium (C) and high (B) world oil price scenarios, as tar sand oil does not become competitive with imported oil under the low (D) world oil price assumption.

A rising real world oil price (in 1978 dollars) will at some point in time reach a minimum-acceptable tar sand oil price level, which in real terms (1978 dollars) does not change during the forecast period.

Highly upgraded tar sand oil is very nearly competitive, when the minimum-acceptable price for it matches the world oil price. Actually, at this point in time, a tar sand operator could expect to receive 20 cents

per barrel less at his upgrading facility in Utah than the price of imported oil landed on the Gulf Coast (as explained in the section "Tar Sand Oil Value and Transportation Cost"). A few months later he could get the full minimum acceptable price.

With passage of time, the value of mildly upgraded tar sand oil rises in a fashion similar to the rise in world oil price. However, at any instant during the forecast period, it has a considerably lower value at the upgrading site in Utah than imported oil landed on the Gulf Coast (see Table 1). Accordingly, as shown in Table 2, the price obtainable by a tar sand operator for a mildly upgraded product at his Utah facility does not reach the minimum-acceptable tar sand oil price level until 2 or 3 years after the world oil price has risen to that level.

Case-D Forecast

Tar sand oil does not become competitive with imported oil during the midterm forecast period in the low world oil price case.

9. UNCERTAINTIES AND ALTERNATE CONCEPTS

Several procedures for recovering oil from U.S, tar sands are under development. As yet, however, we do not know which ones will be used or which ones will predominate in the early stages of a domestic tar sand industry. Reliable cost estimates for the processes to be used can hardly be expected until more performance data have been obtained and innovations incorporated if performance is not satisfactory. Selection of a site for a particular process, or vice versa, may depend, among other things, on the characteristics of the deposit and thickness of the overburden. Information and data on the characteristics of most of the deposits are rather fragmentary.

World oil prices are expected to govern the price obtainable for tar sand oil. During 1979, the price of imported oil has advanced more than most people had anticipated. World oil prices over the midterm period are hard to predict.

The forecasts presented in this report represent one scenario. Others are possible. The material that follows relates to those other possibilities and in some instances reflects suggestions or opinions of tar sand specialists who reviewed a draft of this report.

10. SUMMARY AND CONCLUSIONS

Unless world oil price escalation over the next 15 years proves to resemble the high price path assumed for this study more than the medium trajectory, commercial production of a significant amount of oil from domestic tar sands appears unlikely. The Uvalde, Texas project may be an execption to this generalization. In light of the fact that world oil prices on the average already are higher than the assumed medium (C) price for 1985 (comparing them both in 1978 or 1979 dollars), it would not be too surprising if the world oil price path between 1985 and 1995 should turn out to be close to the high (B) trajectory.

With high (B) world oil prices, production of tar sand oil at a rate of about 50,000 barrels daily appears likely by 1995.

These forecasts reflect the incentive, or lack of it, that would be provided by the assumed world oil prices in comparison with minimum-acceptable prices for tar sand oil. If legislation should be enacted under which the Federal Government would provide additional incentives, the rate of commercial tar sand development would be accelerated; also such development might begin earlier. Production forecasts, to be realistic, then would have to reflect the impact of the additional incentives.

Because there are a number of aspects on which firmer information and data are sorely needed these forecasts are rather tenuous. Only in the high world oil price case does the study forsee a significant amount of tar sand oil production by 1995. If the 1995 production rate for that case were thought likely to be as much as 100 percent above or below the 50,000 barrel per day level seen in this study, changing the forecast by that amount would not have much impact on a projection of total U.S. oil supply in 1995.

It is believed that the forecasts developed in this study are reasonable, and that the procedural framework described herein can be useful in the future for making tar sand oil production forecasts.

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